

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
4 September 2003 (04.09.2003)

PCT

(10) International Publication Number  
**WO 03/072966 A1**

(51) International Patent Classification<sup>7</sup>: **F16C 29/06**,  
19/20, 19/40, 33/38, 33/51, F16H 25/22

(21) International Application Number: PCT/US03/05653

(22) International Filing Date: 27 February 2003 (27.02.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
60/360,155 27 February 2002 (27.02.2002) US

(71) Applicant (for all designated States except US): **THOMSON INDUSTRIES, INC.** [US/US]; Two Channel Drive, Port Washington, NY 11050 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **KIM, Eric** [US/US];

Apartment #1, 40-06 191 Street, Flushing, NY 11358 (US).  
NG, Alison [US/US]; Apartment 3F, 445 East 14 Street, New York, NY 10009 (US).

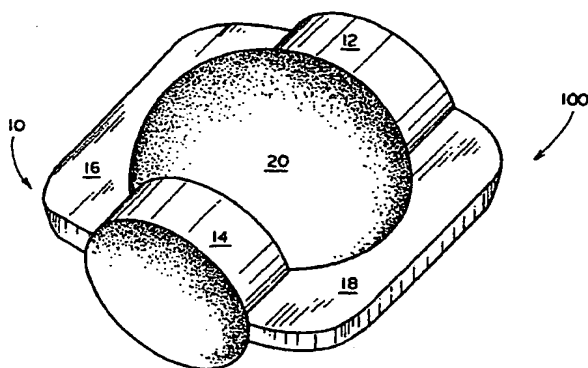
(74) Agents: **BARRESE, Rocco, S. et al.**; Dilworth & Barrese, LLP, 333 Earle Ovington Boulevard, Uniondale, NY 11553 (US).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

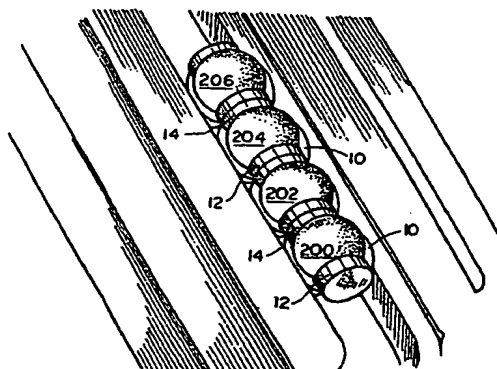
(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

[Continued on next page]

(54) Title: SEGMENTED BALL/ROLLER GUIDE FOR A LINEAR MOTION BEARING



(57) Abstract: A guide (10) associated with a linear motion and screw system is configured to at least partially surround one of a plurality of rolling elements (20) so as to prevent ball-to-ball contact between the one rolling element and adjacent rolling elements during displacement of the rolling element along a circulation ball track.



WO 03/072966 A1

BEST AVAILABLE COPY



European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

**Published:**

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

**SEGMENTED BALL/ROLLER GUIDE FOR A LINEAR MOTION BEARING****CROSS-REFERENCE TO RELATED APPLICATION**

5           This application is based on U.S. Provisional Application No. 60/360,155 filed on February 27, 2002 and fully incorporated herein by reference.

**BACKGROUND OF THE INVENTION**

10       1.     Field of the Invention

[0001] The present invention relates generally to anti-friction linear motion bearing assemblies. More particularly, the present invention is directed to a segmented ball/roller guide assembly utilized to eliminate vibrations caused by ball-to-ball contact in linear motion bearings.

15       2.     Description of the Related Art

[0002] Linear bearings or ball screws are well known for their significant reduction in dynamic and static friction versus plain bearings or lead screws under load. There are different types of linear bearings and ball screws offered on the market today. However, they share a common focus to control ball recirculation properly to provide smooth linear or rotary motion.

[0003] Typical linear rolling bearing assemblies include a series of rolling elements moving about a circulation path which circulation path is formed in the periphery of a track member and a surrounding and enclosing bearing cover confining the rolling elements in their recirculation path. In order to achieve an accurate linear motion, the axis of the bearing assembly must be precisely aligned with the desired direction of motion along the supported structure. In addition this precise alignment also minimizes skewing forces acting on the bearing assembly, which skewing forces tend to reduce the load/life performance of the bearing assembly.

[0004] Installation of such bearing assemblies on a supporting structure (i.e., shaft, splined shaft, guideway or rail) typically involves precision machining of locating

surfaces in order to properly align the bearing assembly on the supporting structure. Such bearing assemblies are typically installed in sets, each comprised of a number of variously facing bearings such as to engage a series of surfaces on the supporting structure (i.e., such as above and below a supporting surface and/or along a lateral edge of a supporting surface). In such instances it is usual to provide a bearing adjustment for enabling precision adjustment of the bearing assembly on the supported structure and also for establishing a proper bearing pre-load by adjusting an opposing bearing assembly for reasons well known to those skilled in the art. In such installations, considerable precision machining of the supported structure is necessitated which is difficult and expensive to accomplish on the supporting structures.

[0005] Many of the disadvantages discussed were overcome in a linear motion bearing structure disclosed, among others, in U.S. Patent Nos. 5,346,313; 5,558,442; 5,613,780 issued to Alison Ng and commonly owned by Thomson Industries, Inc., and fully incorporated in this application by reference. The above-identified patents, and particularly the U.S. Patent 5,613,780, disclose a linear motion bearing assembly comprising a plurality of ball retainer segments including at least one ball track having a load bearing portion, a return portion and a turnaround portion. A plurality of individual balls is then disposed in the ball track to enable the linear bearing to provide low friction motion.

[0006] Such low friction is particularly advantageous in structures related to biased linear motion bearing assemblies of the type, which support a carriage or a pillow block for linear movement along an elongated splined shaft. These bearing assemblies can either be of the open type or the closed type.

[0007] Typically, in the linear bearing assemblies, as disclosed in the above-identified patents, the ball-to-ball contact in the ball track generates adverse conditions when the bearing is in operation. The ball-to-ball contact generates mechanical and/or acoustic vibrations. Radial bearing industries created ball cage technology to eliminate vibration

due to ball-to-ball contact. However, recent developments in linear bearing technologies are working toward elimination of the ball-to-ball contact itself.

5 [0008] One such development is a rolling element chain, also known as a ball chain. Rolling element chains are designed to contain a row of rolling elements, i.e., a ball, as one subassembly with separators between the rolling elements to avoid ball-to-ball contact. An example of one such rolling element chain is disclosed in U.S. Patent No. 5,947,605 to Shirai. The rolling element chain is made usually from very flexible material to allow ball recirculation. Additionally, careful material selection improves the vibration dampening characteristics of the ball chain.

10 [0009] As much as it is beneficial to the reduction of noise or vibration, the rolling element chain also has its drawbacks. The rolling element chain does not provide designers with much freedom in designing ball track geometry. Due to the single chain mechanism, rolling elements must follow a track geometry that is normal or nearly normal to the direction of an applied load on the ball track. This restricts the location of the return track geometry for the ball track and often results in an unwanted outside bearing envelope dimension increase or modification due to the location of return geometry for the rolling elements. If the bearing requires a very strict return geometry away from the direction normal to the applied load on the ball track, the rolling element chain must be made from very flexible material to allow more twist. However, this is a very undesirable design due to long term effects on the material when it is twisted constantly.

25 [00010] Another development towards the elimination of ball-to-ball contact in linear motion and ball screw systems is a ball spacer. Ball spacers are individual pieces of a material, such as a resin or polymer, which separate rolling elements in a bearing or ball screw. Ball spacers allow elimination of ball-to-ball contact without the restrictions provided by the rolling element chain. Individual ball spacers do not have connections between them like the rolling element chain and allow designers to implement ball-to-ball separators without major change in ball track geometry.

5 [00011] Although ball spacers allow more freedom in designing ball return geometry, they do have disadvantages. Due to the use of individual spacers, designers must ensure the spacers will not fall out of its position during operation. If the spacers are dropped out of its position between the balls to the bottom or sides of the ball track, they will create severe impediments to linear motion. This could result in a catastrophic failure on the bearings.

10 [00012] U.S. Patent No. 6,352,367 illustrates the above-discussed drawback by disclosing a spacer located between adjacent rolling elements and configured so that if the distance between the balls exceeds the outer dimension of the spacer, it can be easily displaced off a ball track, which leads to the consequences discussed above.

### SUMMARY OF THE INVENTION

15 [00013] Accordingly, it is an objective of the present invention to provide a new ball-to-ball separator technology, which will eliminate the disadvantages of the prior art rolling element chains and ball spacers.

20 [00014] It is another object of the present invention to provide a segmented ball/roller guide for eliminating ball-to-ball contact in linear motion bearings.

25 [00015] It is a further object of the present invention to provide a segmented ball/roller guide for reducing mechanical and/or acoustic vibrations in linear motion bearings.

[00016] It is yet another object of the present invention to provide a segmented ball/roller guide which allows greater flexibility in designing return track geometry.

30 [00017] The inventive ball/roller guide assembly has a guide configured to support and guide at least one rolling element so that, even if a distance between adjacent rolling

elements displaceable along a ball track becomes large enough for the guide to drop off the track, it remains on the track. Accordingly, since the guide is prevented from unacceptable displacement that, otherwise, could result in impediments to the linear motion, it maintains the desired alignment between adjacent rolling elements along the ball track eliminating.

[00018] The segmented ball/roller guide of the present invention includes a first spacer member, a second spacer member and at least one connection member for connecting and supporting the first and second spacer at an equal diametrical distance around a ball bearing. The first and second spacer members are formed generally in a disc-like shape and may be formed with at least one concave surface so when assembled the ball bearing will be rotatably held within the segmented ball/roller guide. Preferably, the guide is dimensioned to maintain a substantially continuous sliding contact with the thus supported ball bearing. In use, the ball bearing will circulate on a ball track of a linear motion bearing with the spacers preventing ball-to-ball contact. Since each segmented ball/roller guide includes two spacer members, only one segmented ball/roller guide is required for every other ball of a plurality of balls placed on the ball track of a linear motion bearing. Additionally, the connection member acts as a guide for the ball when circulating around the ball track.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

[00019] The above and other objects, features, and advantages of the present invention will become more apparent in light of the following detailed description of exemplary embodiments thereof taken in conjunction with the attached drawings in which:

[00020] FIG. 1 is a perspective view of a first embodiment of a segmented ball guide assembly in accordance with the present invention;

[00021] FIG. 2 is a plan front view of the first embodiment of a segmented ball guide assembly in accordance with the present invention;

[00022] FIG. 3 is a perspective view of the segmented ball guide of FIG. 1 with the ball removed;

[00023] FIG. 4 is a perspective view of the support/guide structure of the segmental ball guide shown in FIG. 1 in accordance with the present invention;

5 [00024] FIG. 4A is a cross-sectional view taken along lines I-I in FIG. 4;

[00025] FIG. 5 is a perspective view of another embodiment of a support/guide structure of a segmented ball guide in accordance with the present invention;

[00026] FIG. 6 is a perspective view of still another embodiment of a support/guide structure of a segmented ball guide in accordance with the present invention;

[00027] FIG. 7 illustrates a plurality of segmented ball guide assemblies located in a load bearing portion of a ball track of a linear bearing assembly;

[00028] FIG. 8 is an enlarged view of FIG. 7; and

10 [00029] FIG. 9 is a perspective view of a still another embodiment of a segmented ball guide in accordance with the present invention.

### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

[00030] Preferred embodiments of the present invention will be described hereinbelow with reference to the accompanying drawings. In the following description, well-known functions or constructions are not described in detail to avoid obscuring the invention in unnecessary detail. It is provided that identical elements are structurally and functionally equivalent throughout the drawings.

25 [00031] Referring to the FIGS 1-8, a segmented ball/roller guide in accordance with the present invention is identified generally by the reference numeral 10.

[00032] FIGS. 1-5 illustrates a segmented ball/roller guide assembly 100 with a ball bearing contained therein. The segmented ball/roller guide 10 of the present invention includes at least one first spacer member 12. While the first spacer member 12 can completely or partially surround a rolling element, such as a ball bearing 20, as will



be discussed hereinbelow, many of the inventive modifications of the support/guide 10 include a second spacer 14. The spacers 12 and 14 are spaced from one another along a travel direction and function as a guard preventing contact between adjacent ball bearings 20 travelling along a track. The distance between the spacers 12 and 14 may be selected so that it is at least slightly greater than the outer diameter of the ball bearing 20. As a result, at least the trailing portion of the guide 10 maintains a substantially continuous sliding contact with the ball bearing 20 without detrimentally affecting the rotation of the ball bearing. Preferably, as a result of the geometry of the spacers 12, 14 and the ball bearing 20, the former are spaced at a uniform radial distance around the ball bearing 20 and are juxtaposed with its leading 23 and trailing 21 segments or regions, respectively. To maintain such a uniform distance, the inventive assembly includes at least one first connection member 16 (FIG. 5), but, preferably, two connection members 16 and 18, as better illustrated in FIGS. 1-4.

**[00033]** To reliably guide the ball bearing 20, the first and second spacer members 12, 14 may be formed with seats each having a respective concave surface 22, 24 (see FIG. 3) extending complementary to the regions 21, 23 of the ball bearings 20. Accordingly, when assembled, the ball bearings 20 will be rotatably held within the segmented guide 10 and, even if a distance between adjacent ball bearings 200-206 (FIG. 8) is unacceptably increased, the guide 10 remains in sliding contact with the guided ball bearing. In practical terms, the guide 10 cannot be displaced from its position between adjacent ball bearings running along a circulation passage of a ball track formed in a bearing carriage regardless of their relative position along the ball track. Preferably, the spacer members 12, 14 will have concave surfaces formed on both sides 24, 26 one to retain the ball 20 and one for contact with an adjacent ball when in motion, the operation of which will be described below. Alternatively, however, the inner surfaces 22, 24 can be flat or even convex to still provide contact with the leading 23 and trailing 21 regions of the ball bearing 20.

**[00034]** FIGS. 4 through 6 illustrate various embodiments of the segmented ball/roller guide. Fundamentally, the variations in the different embodiments are in the

number and structure of the connection members. As shown in FIG. 5, the ball/roller guide 10 includes only one connection member 16, whereas the embodiment shown in FIG. 6, has one of the connection members recessed. The geometry and particular structure of the connection members 16, 18 depend the particular design of the ball track. Advantageously, bottoms 17 and 19 of the connection elements 16, 18 are narrowed to have an arcuate or substantially conical shape (FIG. 4A), which will reduce a contact area and, consequently, frictional forces between the connection elements and side surfaces of the ball track. Operationally, the embodiments shown in FIGS. 4 through 6 are functionally similar. The spacers 12, 14 as well as connection elements 16 and 18 can be detachably coupled to one another by various fasteners. In addition, the guide can be configured to have all of the components machined with surfaces extending complementary to and matching one another during the assembly of the guide 10. For example, the spacers 12, 14 each can have recesses receiving complementary formed projections of the connection elements 16, 18. Alternatively, the components of the ball/roller guide can be made integrally or unitarily from a variety of materials including engineering polymers and thermoplastics characterized by a low-friction coefficient.

[00035] In use, the segmented ball/roller guide will circulate on a ball track of a linear motion bearing with the spacer members preventing ball-to-ball contact. FIGS. 7 and 8 show a ball retainer segment or bearing carriage 72 of a linear bearing assembly 70. The ball retainer segment 72 includes a ball track 74 having a load bearing portion 76, a return portion 78 and a turnaround portion 80. Since each segmented ball/roller guide 10 includes two spacer members 12 and 14, only one segmented ball/roller guide 10 is required for every other ball of a plurality of balls placed on the ball track 74 of linear bearing 70. Spacer members 12 and 14 will retain a first ball 200 and a second ball 202 will circulate in the outer concave surface 26 of spacer member 14 and an outer concave surface (not shown) of spacer member 12 of the next adjacent guide 10. As the balls 200, 202, 204, 206 circulate to provide linear motion the spacer member 12, 14 will eliminate ball-to-ball contact. Additionally, the connection member or members 16, 18 act as a guide for the balls 20 when circulating around the ball track 74 while preventing the displacement of the balls off the track.

[00036] FIG. 9 illustrates a fifth embodiment of the segmented ball guide. As shown in FIG. 9, the guide 90 is formed as an annular member having an inner surface 92, an outer surface 94, a top surface 96 and a bottom surface 98. The guide is preferably formed with flat surfaces. As a modification to the annular member, the inner surface 92 and outer surface 94 may be formed in a concave shape to minimize the spacing between balls 20. As with the other embodiments described above, the annular member 90 will act as a guide for the balls when circulating around the ball track.

[00037] The present invention allows the benefits of both the rolling element chain and ball spacers to be used without the associated disadvantages. The segmented ball/roller guide of the present invention acts in very much the same manner as the rolling element chain without the disadvantage of limited twist. By not having the individual segmented ball guide assemblies connected to each other, an infinite amount of twist between the ball guides is possible resulting in a great amount of flexibility in designing the return track geometry.

[00038] Furthermore, the segmented ball/roller guide is not in danger of falling out of position when the gap between rolling elements, i.e. bearing balls, increases over time as occurs with ball spacers. This is achieved by the connection member or members 16, 18 between the ball spacer members. This allows designers of linear bearings to ease the tolerance requirements in ball track geometry. This also allows designers freedom to choose either hard or soft material for the segmented ball/roller guide since changes in the gap distance between balls will not result in catastrophic failure.

[00039] While the present invention has been described in detail with reference to the preferred embodiments, they represent mere exemplary applications. For example, the ball bearing 20 can be incorporated in radial bearings. Outer surface 85 (FIG. 9) of at least one of the spacers 12, 14 can be recessed along the trailing or leading regions 23, 21 of the rolling element 20 so that a shape and size of recess allows an adjacent ball bearing to be guided and supported. Thus, it is to be clearly understood that many variations can

be made by anyone having ordinary skill in the art while staying within the spirit and scope of the present invention.

**WHAT IS CLAIMED IS:**

1. A guide assembly for at least one rolling element displaceable along a path, comprising a guide configured to guide the at least one rolling element along the path while maintaining a substantially continuous sliding contact therewith along the path.  
5
2. The guide assembly of claim 1, wherein the guide includes at least one spacer extending between diametrically opposite leading and trailing regions of the at least one rolling element.  
10
3. The guide assembly of claim 2, wherein the at least one spacer is endless.
4. The guide assembly of claim 2, wherein the at least one spacer is discontinuous along one of the leading and trailing regions of the at least one rolling element.  
15
5. The guide assembly of claim 2, wherein the at least one spacer has opposite inner and outer sides extending either parallel to one another or converging toward the bottom so as to reduce a contact surface of the bottom.  
20
6. The guide assembly of claim 5, wherein the bottom has an arcuate or substantially conical.
7. The guide assembly of claim 5, wherein the inner side of the at least one spacer has at least one portion juxtaposed with a respective one of the leading and trailing regions of the rolling element and being curved to maintain the substantially continuous contact with the respective one of the leading and trailing regions.  
25
8. The guide assembly of claim 7, wherein the curved portion of the spacer has a surface extending complementary to the respective one of the leading and trailing regions of the at least one rolling element.  
30

9. The guide assembly of claim 5, wherein the outer side of the at least one spacer has a region provided with a curved surface configured to slidingly support a second rolling element located immediately upstream or downstream from the at least one rolling element.

5

10. The guide assembly of claim 2, wherein the guide further comprises:  
a second spacer juxtaposed with a respective one of the leading and trailing regions of the at least one rolling element, the second spacer being configured to maintain the substantially continuous contact with the at least one rolling element, and  
at least one connector extending between and coupling the at least one and second spacers to ensure the substantially continuous contact between the at least one rolling element and the second spacer during the displacement of the at least one rolling element along the path.

10

15

11. The guide assembly of claim 10, wherein the guide further comprising a second connector spaced from the at least one connector and extending between the at least one and second spacers, so as the at least one rolling element is surrounded by the guide.

20

12. The guide assembly of claim 11, wherein one of the at least one and second connectors is discontinuous.

25

13. The guide assembly of claim 11, wherein the at least one and second connectors and the at least one and second spacers are detachably assembled or unitarily formed.

30

14. The guide assembly of claim 11, wherein the guide is made from materials selected from the group consisting of polymers, thermoplastics and a combination of polymers and thermoplastics and characterized by a low-friction coefficient.

15. A linear motion and ball screw system comprising:

an endless circulation passage;  
a plurality of rolling elements displaceable in the endless circulation passage  
along a travel direction; and

at least one guide receiving the plurality of rolling elements and configured to  
5 prevent ball-to-ball contact between the one rolling element and upstream and  
downstream rolling elements which are located adjacent to the one rolling element.

16. The linear motion and ball screw system of claim 15, wherein the at least one  
guide comprises:

10 a leading spacer located between the at least one rolling element and the  
downstream rolling element and spanning the circulation passage;

a trailing spacer located between the at least one rolling element and the  
upstream rolling element and spanning the circulation passage; and

15 at least one connector extending between and connected to the leading and  
trailing spacers and extending laterally beyond the circulation passage to at least partially  
enclose the at least one rolling element.

17. The linear motion and ball screw system of claim 16, further comprising a  
second connector spaced diametrically from the at least one connector and extending  
20 between the leading and trailing spacers and laterally beyond the circulation passage.

18. The linear motion and ball screw system of claim 17, wherein at least one of  
the one and second connectors is discontinuous to reduce friction between the connectors  
and a surface adjacent to the circulation passage.

25 19. The linear motion and ball screw system of claim 16, wherein at least one of  
the leading and trailing spacers has opposite inner and outer surfaces curved inwards  
toward one another to form a first seat for the at least one rolling element and a respective  
one of the upstream and downstream rolling elements.

30

20. The linear motion and ball screw system of claim 16, wherein the guide is configured to have the leading and trailing spacers spaced uniformly from a rolling axis of the at least one rolling element.

5           21. The linear motion and ball screw system of claim 16, wherein the at least one rolling element and at least the trailing spacers are in substantially continuous contact during displacement of the at least one rolling element long the circulation passage.

10           22. The linear motion and ball screw system of claim 17, wherein the leading and trailing spacers and the one and second connectors are detachably connected to one another or fixed to one another.

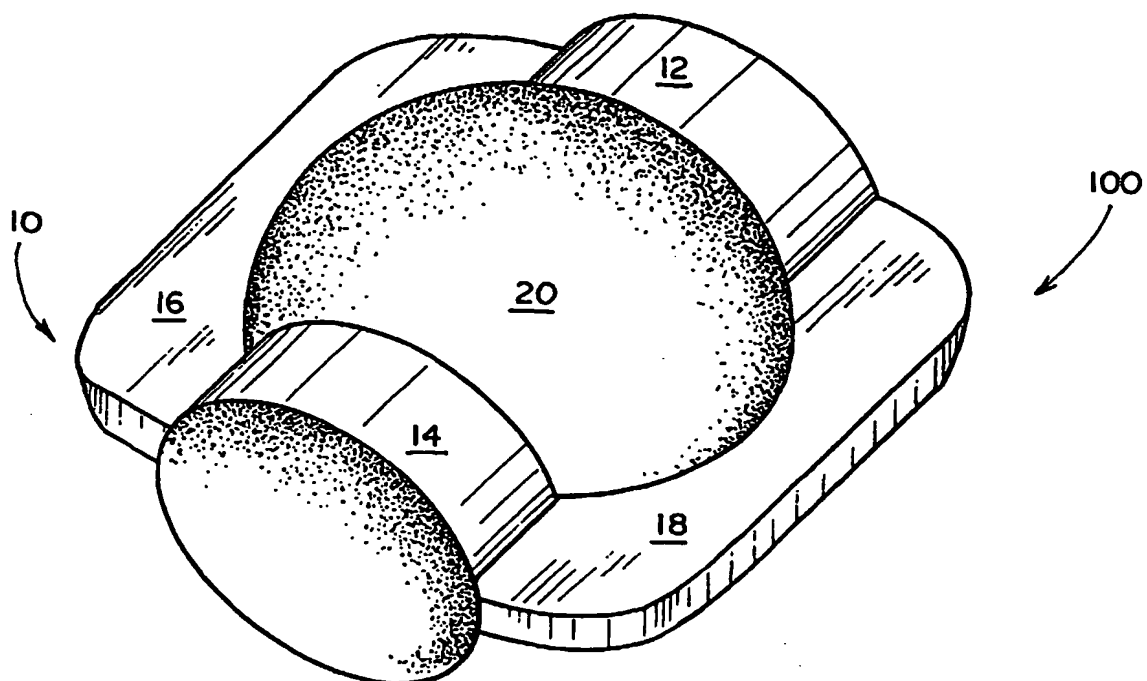
          23. A linear motion bearing comprising:  
a bearing carriage provided with at least one endless circulation passage;  
15           a series of individual bearing balls movable along the circulation passage; and  
a plurality of guides slidable along the circulation ball passage and arranged to have every other bearing ball guidingly supported in a respective guide and to prevent adjacent bearing balls from ball-to-ball contact during displacement of the bearing balls.

20           24. The linear motion bearing of claim 23, wherein the plurality of guides each comprises:  
a leading spacer spanning the circulation passage;  
a trailing spacer located upstream from the leading spacer and spanning the circulation passage; and  
25           at least one connector extending between and connected to the leading and trailing spacers and extending laterally beyond the circulation passage, whereas, as the series of bearing balls moves along the circulation passage, the guides and the bearing balls are in substantially continuous contact.

30           25. The linear motion bearing of claim 24, further comprising a second connector spaced diametrically from the at least one connector.



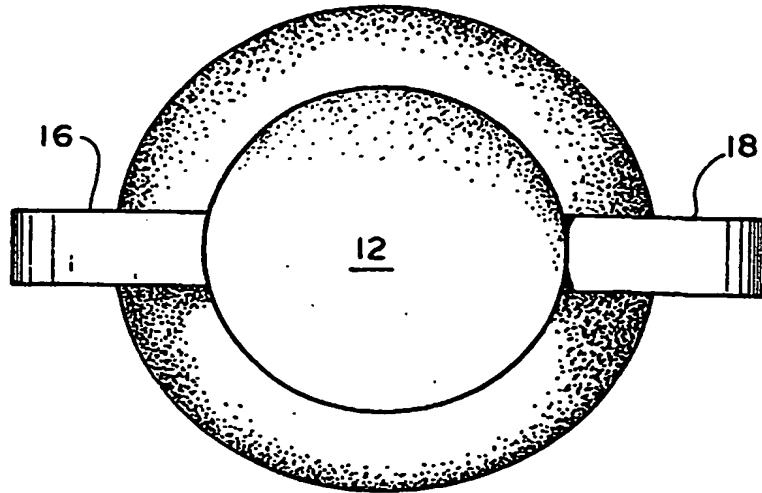
1 / 5



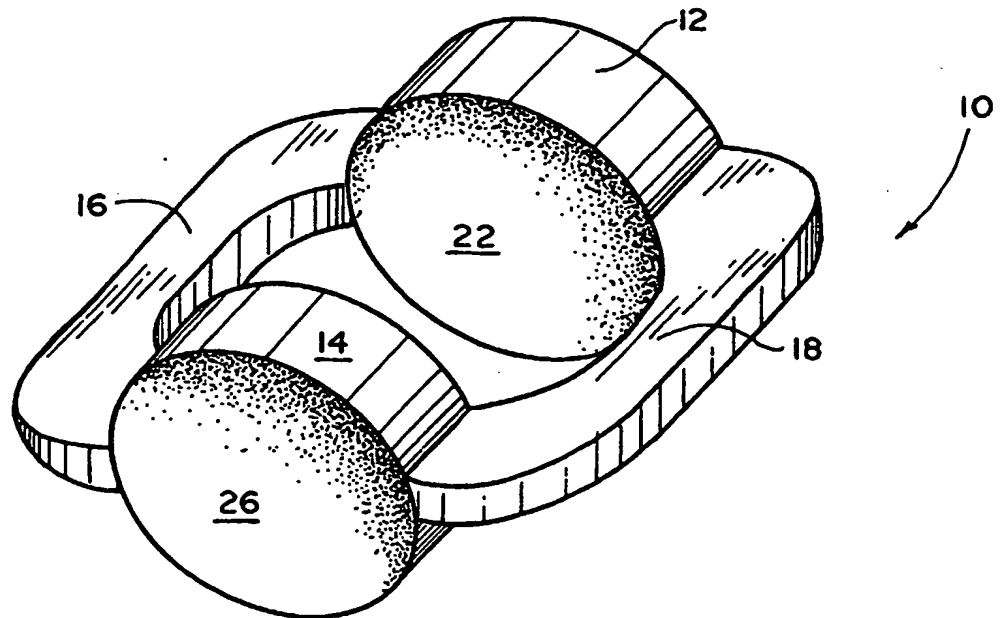
F I G . 1

SUBSTITUTE SHEET (RULE 26)

2 / 5



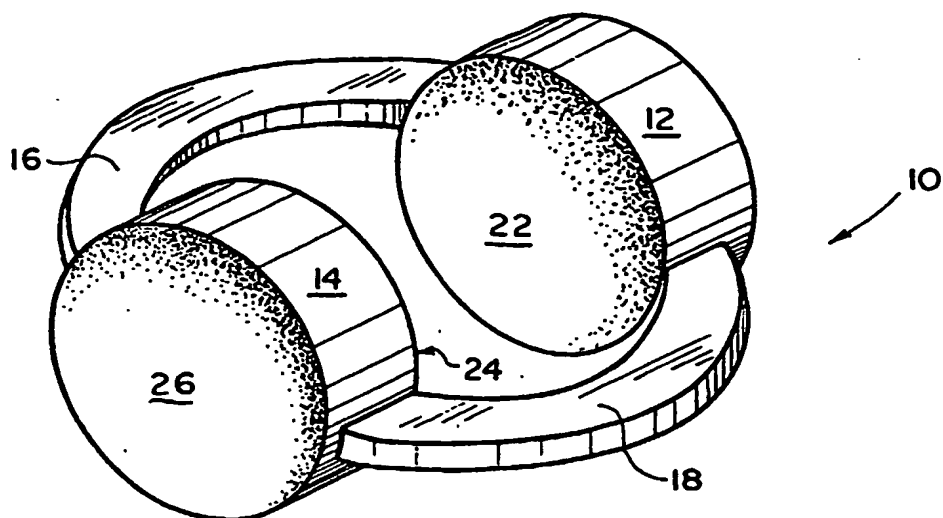
F I G . 2



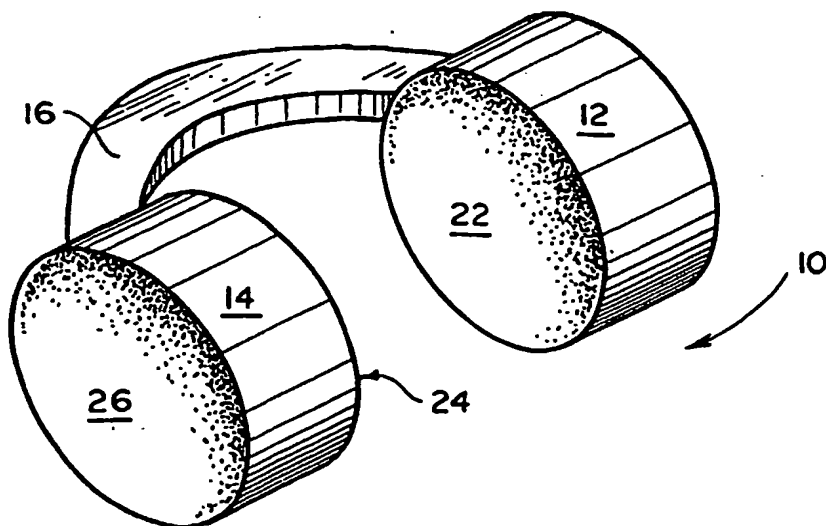
F I G . 3

SUBSTITUTE SHEET (RULE 26)

3 / 5



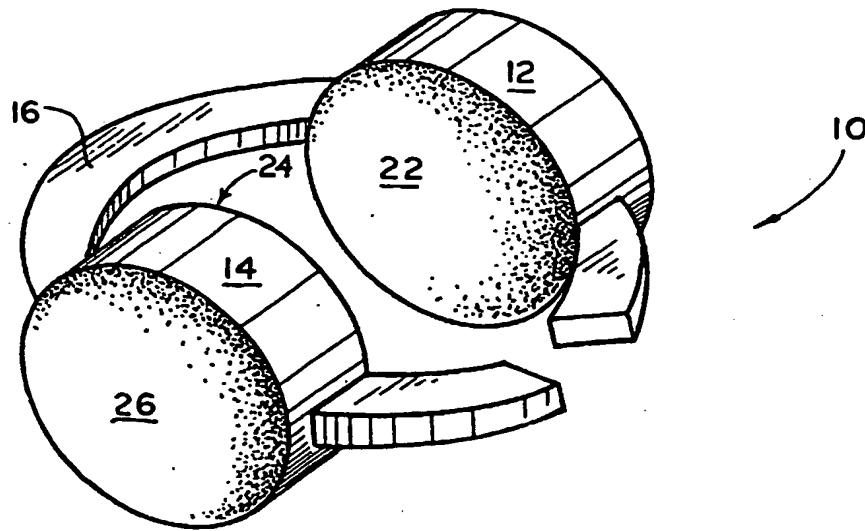
F I G . 4



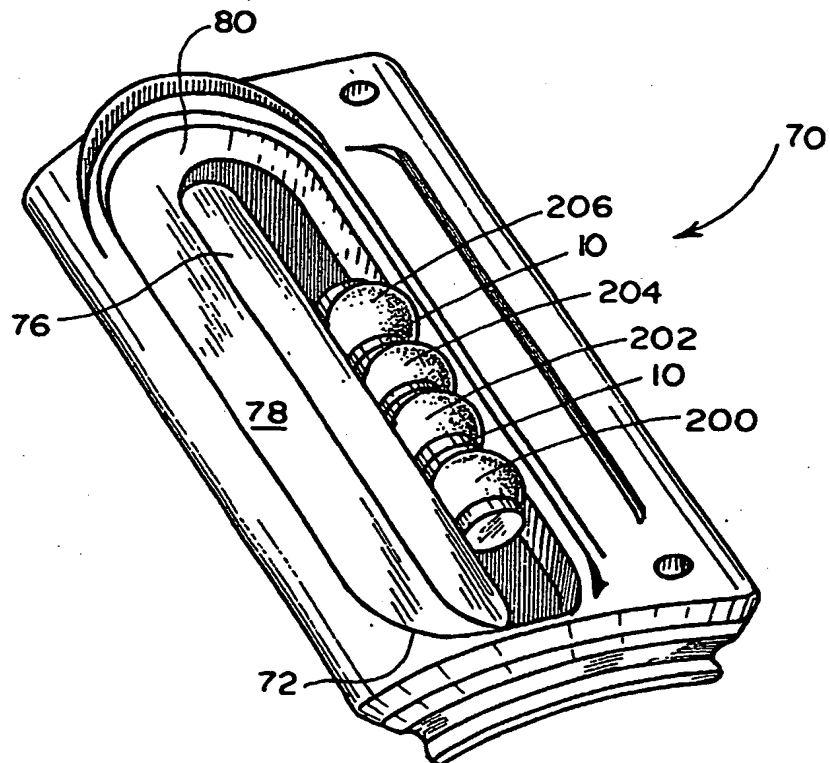
F I G . 5

SUBSTITUTE SHEET (RULE 26)

4 / 5



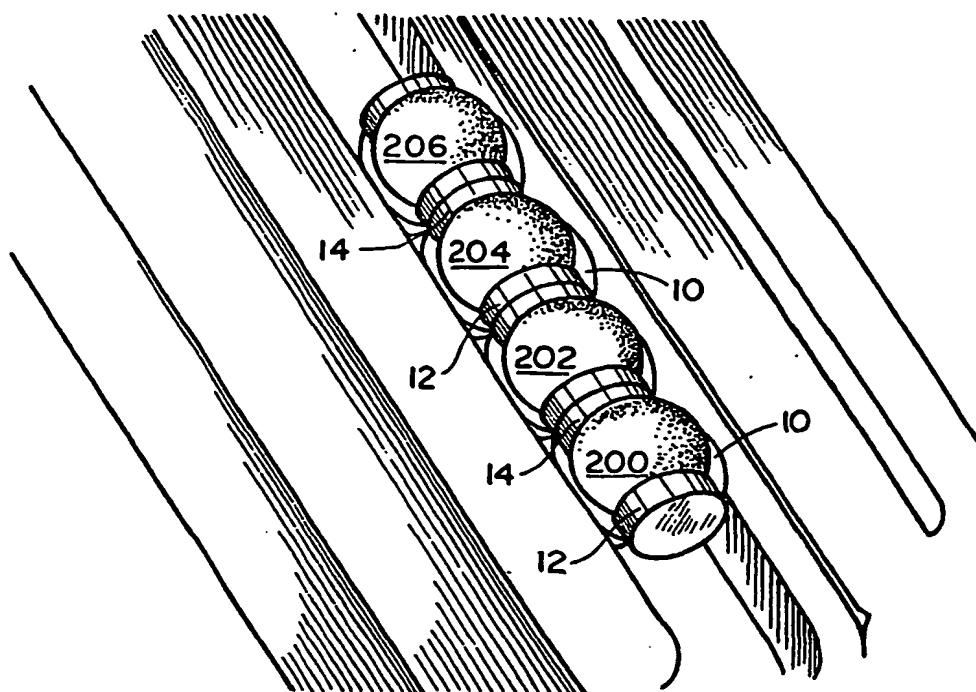
F I G . 6



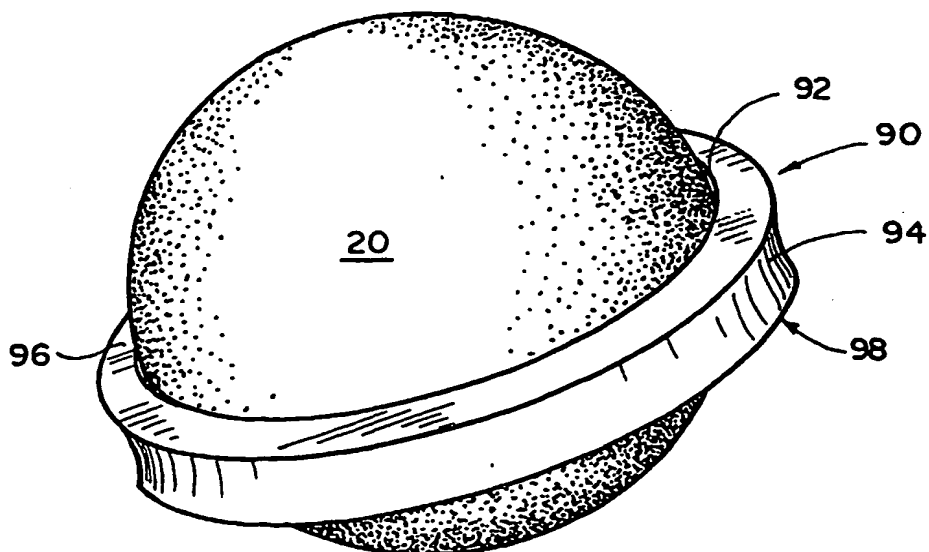
F I G . 7

SUBSTITUTE SHEET (RULE 26)

5 / 5



F I G . 8



F I G . 9

SUBSTITUTE SHEET (RULE 26)

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC 7 F16C29/06 F16C19/20 F16C19/40 F16C33/38 F16C33/51  
F16H25/22

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F16C F16H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, EPO-Internal, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 024 305 A (THK CO LTD) 2 August 2000 (2000-08-02)  column 5, line 51 -column 6, line 18; figures 1-15 ----	1-3, 5-11, 13-17, 19-25
X	US 6 102 572 A (HIDANO KENGO) 15 August 2000 (2000-08-15)  column 6, line 29 - line 49; figures 1-9 ----	1,2, 4-11, 13-15
A		16,17, 21,22
X	US 5 947 605 A (SHIRAI TAKEKI) 7 September 1999 (1999-09-07) cited in the application the whole document ----	1,2, 4-10,15, 16,19-22
	----	
	-/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

**\* Special categories of cited documents:**

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*A\* document member of the same patent family

Date of the actual completion of the international search

17 June 2003

Date of mailing of the international search report

25/06/2003

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Baron, C

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 846 880 A (THK CO LTD) 10 June 1998 (1998-06-10)  column 6, line 6 -column 7, line 16; figures 1-6 ---	1,2, 5-11, 13-17, 19-22
X	EP 1 048 860 A (THK CO LTD) 2 November 2000 (2000-11-02) the whole document ---	1,2,5-9, 15,23
A P,X	& US 6 352 367 B1 5 March 2002 (2002-03-05) cited in the application ---	14,19-21
X	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 01, 31 January 2000 (2000-01-31) & JP 11 270559 A (NIPPON SEIKO KK), 5 October 1999 (1999-10-05) abstract ---	1,2, 10-13, 15-18, 20-22
A	US 5 927 858 A (AGARI NORIMASA) 27 July 1999 (1999-07-27) column 6, line 49 - line 64; figures 2,3 ---	4-9,19, 21
X		15,23
A	US 2001/007685 A1 (KASUGA SHINICHI ET AL) 12 July 2001 (2001-07-12) page 4, right-hand column, line 30 - line 36; figure 6 ---	4-9,19, 21
X		15,23
A	US 5 613 780 A (NG ALISON) 25 March 1997 (1997-03-25) cited in the application ---	
A	US 5 558 442 A (NG ALISON) 24 September 1996 (1996-09-24) cited in the application ---	
A	US 5 346 313 A (NG ALISON) 13 September 1994 (1994-09-13) cited in the application -----	

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
EP 1024305	A	02-08-2000	JP	2000220636 A	08-08-2000
			EP	1024305 A2	02-08-2000
			KR	2000053650 A	25-08-2000
			TW	417011 B	01-01-2001
			US	6247846 B1	19-06-2001
US 6102572	A	15-08-2000	JP	11247855 A	14-09-1999
US 5947605	A	07-09-1999	JP	10002332 A	06-01-1998
			CN	1199451 A , B	18-11-1998
			EP	0845611 A1	03-06-1998
			WO	9748913 A1	24-12-1997
EP 0846880	A	10-06-1998	JP	3243415 B2	07-01-2002
			JP	10009264 A	13-01-1998
			EP	0846880 A1	10-06-1998
			US	6155718 A	05-12-2000
			CN	1196779 A , B	21-10-1998
			WO	9749931 A1	31-12-1997
			TW	470820 B	01-01-2002
EP 1048860	A	02-11-2000	JP	2000314420 A	14-11-2000
			EP	1048860 A1	02-11-2000
			US	6352367 B1	05-03-2002
JP 11270559	A	05-10-1999	NONE		
US 5927858	A	27-07-1999	JP	10281154 A	20-10-1998
US 2001007685	A1	12-07-2001	JP	2001193814 A	17-07-2001
			JP	2001193740 A	17-07-2001
			DE	10101054 A1	26-07-2001
			US	2003087062 A1	08-05-2003
			US	2003087063 A1	08-05-2003
US 5613780	A	25-03-1997	AT	189733 T	15-02-2000
			AU	6400696 A	30-01-1997
			BR	9609347 A	21-12-1999
			CA	2224810 A1	16-01-1997
			DE	69606642 D1	16-03-2000
			DE	69606642 T2	06-07-2000
			EP	0832367 A1	01-04-1998
			ES	2142074 T3	01-04-2000
			WO	9701713 A1	16-01-1997
US 5558442	A	24-09-1996	US	5346313 A	13-09-1994
			BR	9402862 A	04-04-1995
			CA	2127425 A1	21-01-1995
			DE	69406859 D1	02-01-1998
			DE	69406859 T2	09-04-1998
			EP	0636803 A1	01-02-1995
			HK	1003843 A1	06-11-1998
			JP	7158638 A	20-06-1995
US 5346313	A	13-09-1994	BR	9402862 A	04-04-1995
			CA	2127425 A1	21-01-1995
			DE	69406859 D1	02-01-1998
			DE	69406859 T2	09-04-1998



Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5346313	A	EP 0636803 A1	01-02-1995
		HK 1003843 A1	06-11-1998
		JP 7158638 A	20-06-1995
		US 5558442 A	24-09-1996
<hr/>			

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

☐ BLACK BORDERS

☒ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES

☒ FADED TEXT OR DRAWING

☒ BLURRED OR ILLEGIBLE TEXT OR DRAWING

☒ SKEWED/SLANTED IMAGES

☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS

☐ GRAY SCALE DOCUMENTS

☒ LINES OR MARKS ON ORIGINAL DOCUMENT

☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY

☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**